

Claims

1. A method for measuring a dimension on a substrate, the method comprising the steps of:

providing a nominal pattern comprising an array of features having a primary pitch of period P in a primary direction, wherein said nominal pattern is characterized by a nominal characteristic dimension that repeats at said period P along said primary direction, and said nominal characteristic dimension has a pre-determined variation along a direction orthogonal to said primary direction;

forming a target pattern on the substrate corresponding to said nominal pattern, wherein said target pattern has a substrate characteristic dimension corresponding to said nominal characteristic dimension;

illuminating said target pattern with radiation characterized by at least one wavelength, so as to produce diffracted orders from said target pattern;

providing a relationship between a dimension of interest and a detected variation along said orthogonal direction of one or more non-zeroth diffracted orders in response to a deviation of said substrate characteristic dimension relative to said nominal characteristic dimension;

detecting said variation of said one or more non-zeroth diffracted orders along said orthogonal direction; and

determining said dimension of interest in accordance with said relationship, based on said detected variation of said one or more non-zeroth diffracted orders.

2. The method of claim 1, wherein said illumination comprises more than one wavelength, and said method further comprises detecting variations of said non-zero diffracted orders along said primary direction.

3. The method of claim 1 or claim 2, wherein said target dimension comprises a critical dimension.
4. The method of and of claims 1-3, wherein said detected variation comprises a variation in intensity of said one or more non-zeroth diffracted orders.
5. The method of any of claims 1-4, wherein said nominal pattern comprises a first subpattern comprising subpattern features of a first tone characterized by a nominal length and width, and a second subpattern comprising features of a complementary tone having said nominal length and width, and wherein said method further comprises determining a deviation in process conditions from nominal based on deviations of corresponding target subpattern feature lengths and widths relative to said nominal length and widths.
6. The method of any of claims 1-5, wherein said target pattern comprises a first target portion formed on a first layer of the substrate, said first target portion corresponding to a first portion of said nominal target pattern, and a second target portion formed on a second layer of the substrate, said second target portion corresponding to a second portion of said nominal target pattern, and said dimension of interest comprises an offset of said first target portion relative to said second target portion in comparison to said nominal pattern.
7. The method of claim 6, wherein said detected variation comprises a variation in intensity and phase of said one or more non-zeroth diffracted orders.
8. An apparatus for performing the method of any of claims 1-7, comprising:

a source of radiation for illuminating said target pattern;

a detector for detecting said variation of one or more non-zero diffracted orders;

means for securing the substrate;

means for positioning said source, said substrate and said detector so that said source illuminates said target pattern, and so that said detector detects said variation of one or more non-zero orders of said radiation diffracted from said target pattern.

9. The apparatus of claim 8 further comprising:

a second detector for detecting the zeroth order of said radiation diffracted from said target pattern;

means for positioning said second detector relative to said source and said substrate so that said second detector detects said zeroth order; and

means for determining a second dimension of interest based on said detected zeroth order.

10. The apparatus of claim 8 or claim 9 wherein said apparatus is configured for in-line processing for semiconductor manufacturing.

11. The apparatus of any of claims 9-10 further comprising:

means for determining a deviation in process conditions from nominal process conditions based on said variation of said one or more non-zeroth diffracted orders; and

means for providing adjustments in subsequent process conditions in response to said determined deviation in process conditions.